Integrated Post-Installation Monitoring

Brian Polagye

Northwest National Marine Renewable Energy Center

University of Washington

bpolagye@uw.edu

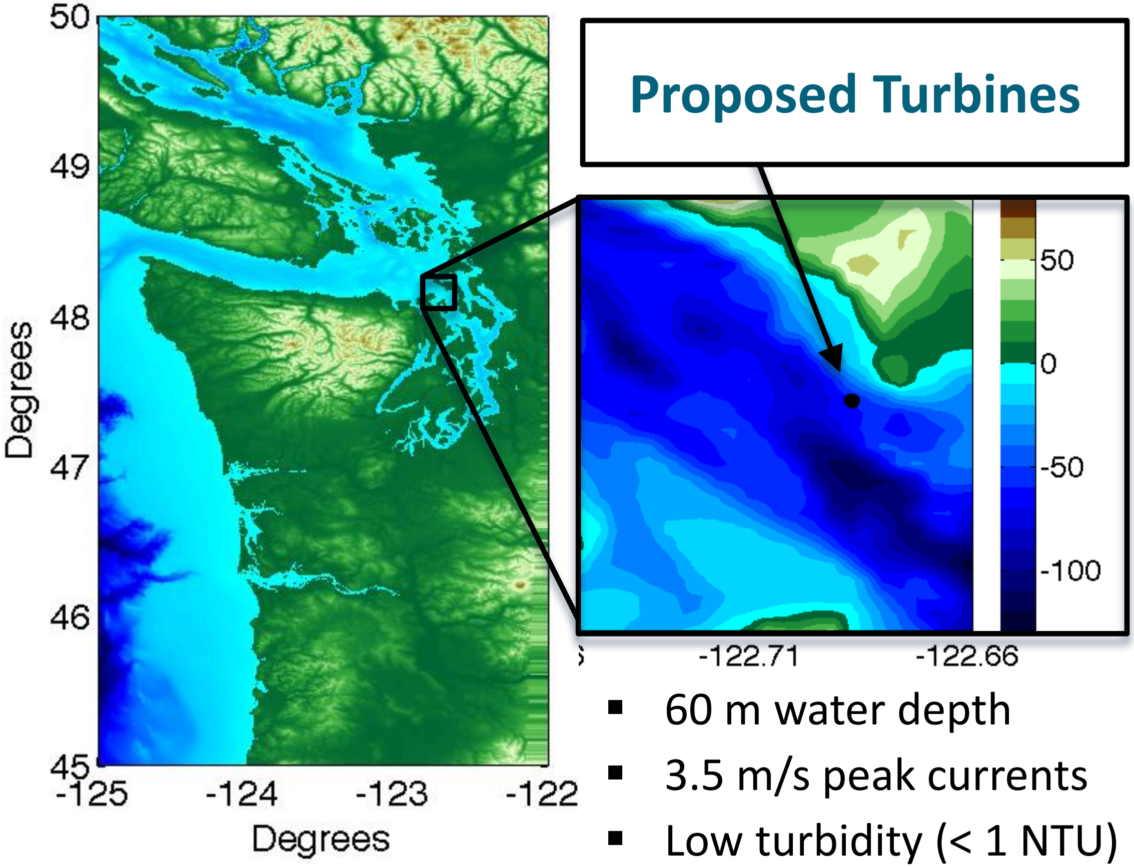
Monitoring Technologies and Strategies for Marine and Hydrokinetic Devices Webinar

September 14, 2011

NNMREC

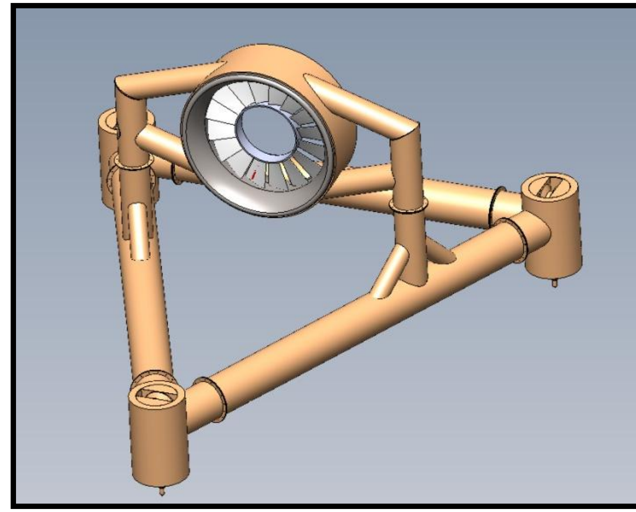
Tidal Energy Project Development

Snohomish PUD/OpenHydro



- 60 m water depth
- 3.5 m/s peak currents
- Low turbidity (< 1 NTU)
- Cable to shore

OpenHydro Technology



- 2 x 6 m turbines
- 250 kW peak power
- Gravity foundation
- 3-5 year deployment

Post-Installation Monitoring

- **At pilot-scale, provide information about high significance/high uncertainty interactions with devices**
  - Key input to risk assessment frameworks
- **Monitoring should not change animal behavior nor affect device operation**
- **Environmental monitoring should not dominate over other project costs**
  - All projects are also demonstrating technical readiness and economic viability
  - Post-installation monitoring requires prioritization

Environmental Concerns

	Device presence: Static effects	Device presence: Dynamic effects	Chemical effects	Acoustic effects	Electromagnetic effects	Energy removal	Cumulative effects
Physical environment: Near-field	▲▲▲	△△	▲▲▲	△	△	▲▲▲	▲▲▲
Physical environment: Far-field	△△	△△	△	△	△	▲▲▲	▲▲▲
Habitat	△△	▲▲▲	△△	△	△△	▲▲▲	▲▲▲
Invertebrates	△△	△△	△△	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Fish: Migratory	△△	▲▲▲	△△	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Fish: Resident	△△	▲▲▲	△△	▲▲▲	▲▲▲	▲▲▲	▲▲▲
Marine mammals	▲▲▲	▲▲▲	△△	▲▲▲	△	△	▲▲▲
Seabirds	△△	▲▲▲	△△	△	△	△	▲▲▲
Ecosystem interactions	△△	△△	△△	△△	▲▲▲	▲▲▲	▲▲▲

Proposed monitoring for Snohomish PUD/OpenHydro demonstration

Commercial-Scale Effects

Polagye, B., B. Van Cleve, A. Copping, and K. Kirkendall (eds), (2011) Environmental effects of tidal energy development.

Dynamic Effects Monitoring

Objectives

- Quantify the risk of blade strike to marine life
- Improve understanding of how marine life responds to device presence
- Both of these should be at the lowest level of taxonomic classification possible

Challenges

- Laboratory and field studies to date suggest blade strike will be an infrequent occurrence
- Difficult and resource-intensive to monitor in the field

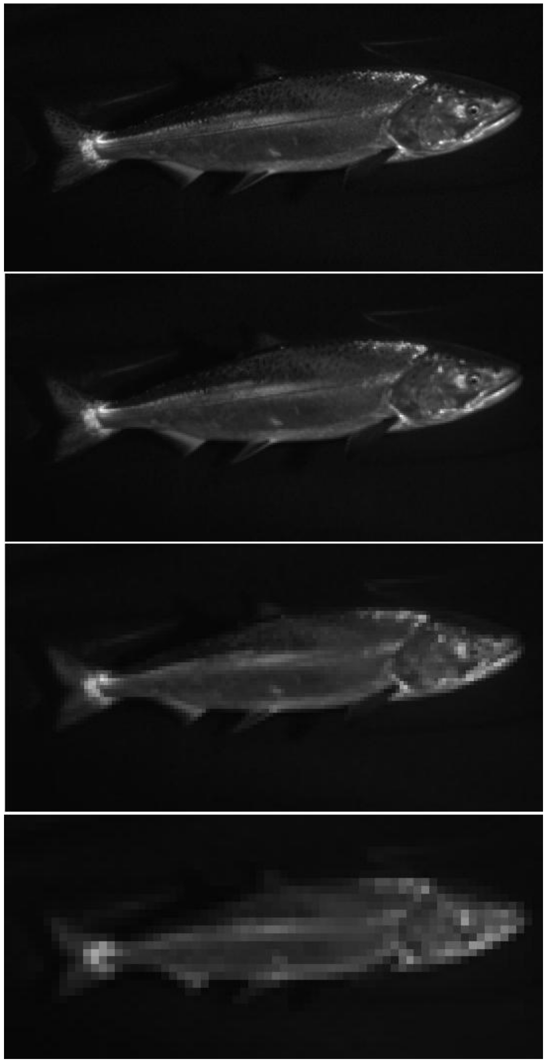
Monitoring Technology

	Underwater Imaging	Active Acoustics	Trawl Surveys	Fish Tags
Prior MHK Experience	OpenHydro (EMEC)	Verdant Power (East River) ORPC (Cobscook Bay)	*None*	OpenHydro (FORCE) Hydro Green (Hastings)
Blade Strike Detection				
Taxonomic Classification	Contrast			
Functional Range	Turbidity and Aeration			Tag Frequency
Behavioral Disturbance	Illumination			
Overall				

Underwater Imaging Considerations

- **Stereo imaging – absolute size, position, and speed**
- **Similarities to trawl ground-truthing and benthic habitat surveys**
  - High relative motion between camera and target
  - Taxonomic classification required
- **Several unique considerations for turbine monitoring**
  - Positioning of lights and cameras relative to turbine
  - Long deployment time (biofouling, durability)
  - Recovery and redeployment instrumentation

Camera and Optics Selection



500 pixels/target
Chinook salmon

250 pixels/target
Chinook salmon?

125 pixels/target
Salmon

62 pixels/target
Fish?

Source: Kresimir Williams, AK Fisheries Science Center

- **2 Mpx machine vision cameras**
  - 10 Hz maximum frame rate
  - Resolution/bandwidth
- **45º FOV lens (in air)**
- **Flat optical port (biofouling)**

Manta G-201 (to scale)

Illumination Selection

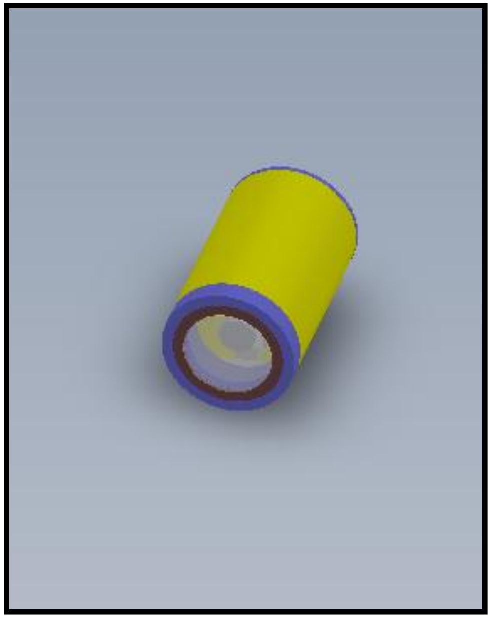
- **Imaging fast moving targets**
  - Short exposure time: 2-50 μs (Gallager, et al. 2004)
  - Large camera-light separation (Jaffe 1988)
- **Full-spectrum strobes (Excelitas MVS 5002)**
  - Four strobes per stereo imaging system
- **Behavioral disturbance is problematic**
  - Considered red, IR, and NIR lighting options
  - Initially, pre-set duty cycle with disturbance analysis
  - As behavior/interactions are better understood, progress to event-based illumination

Biofouling Mitigation Strategies

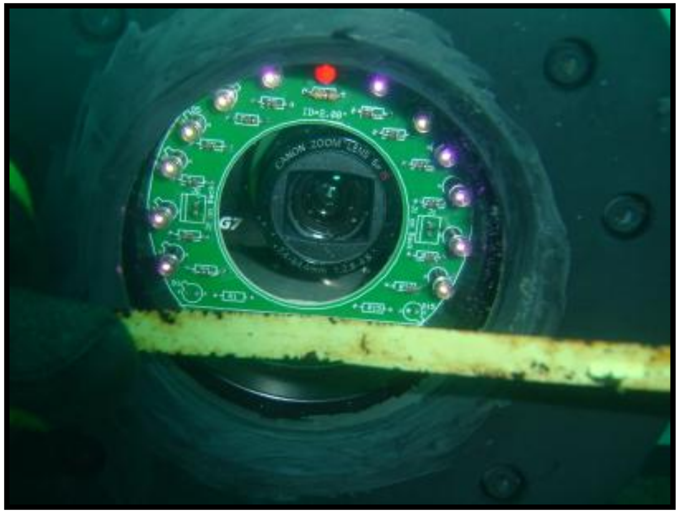
- **Biofilm formation begins immediately after deployment**

Mechanical Wiper

Copper Ring

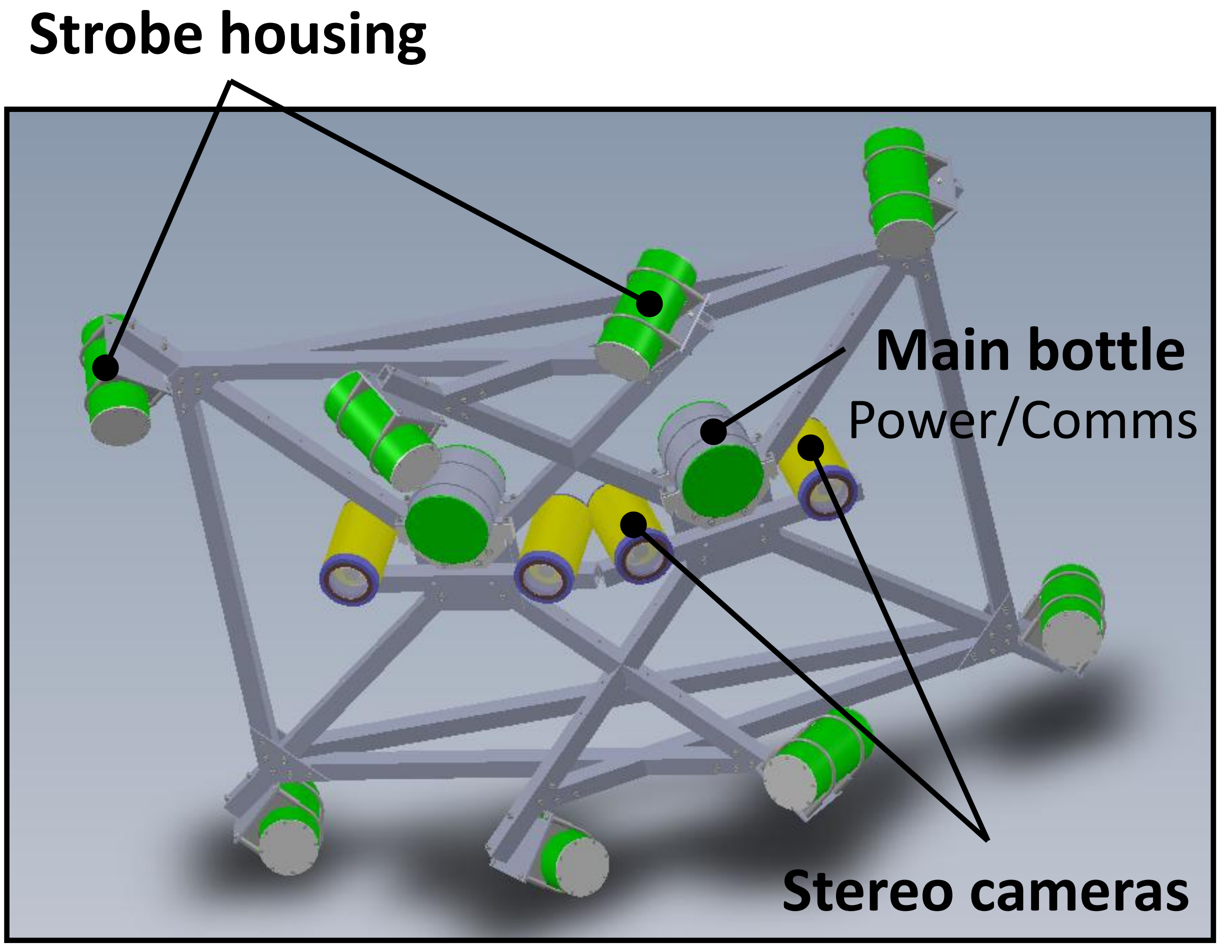


Ultraviolet Lighting



Even with mitigation, performance will degrade with time

System Layout Concept

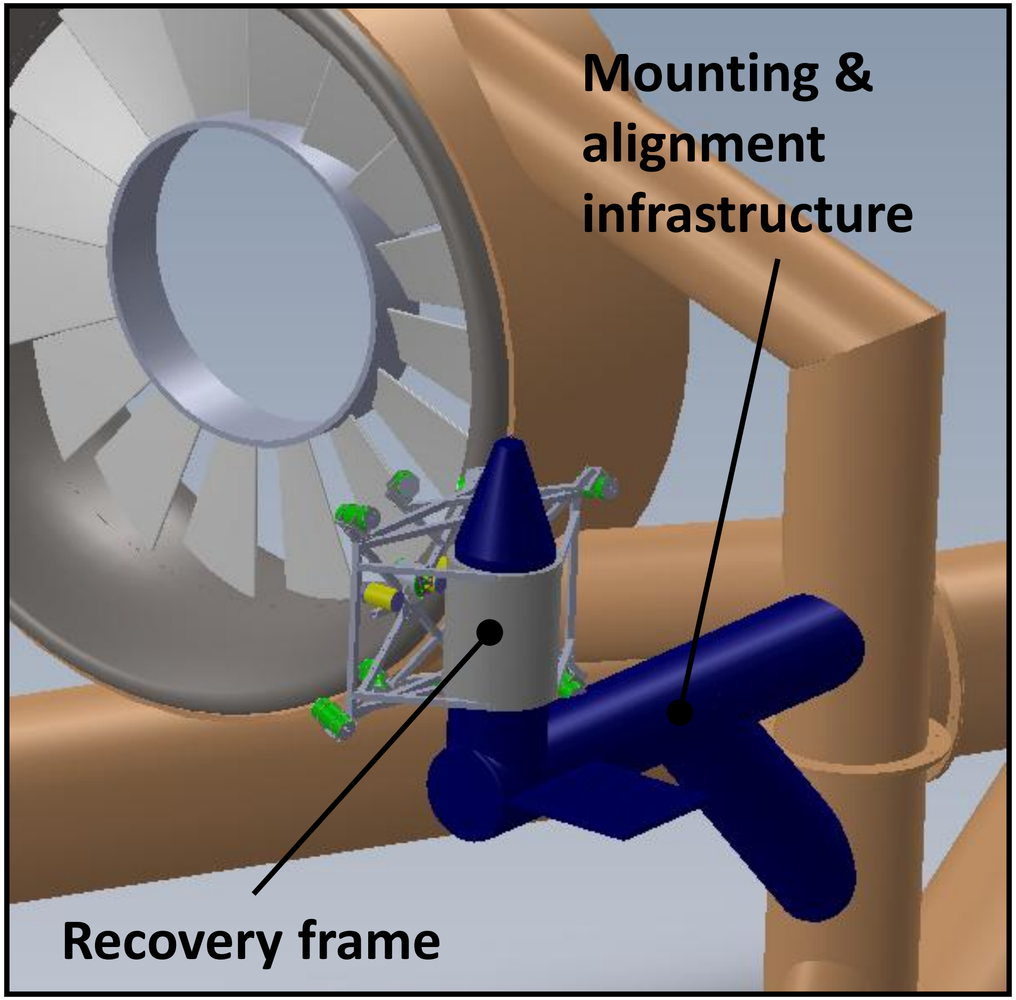


Compact frame concept

- **2 stereo camera systems**
  - Strike detection
  - Taxonomic classification
- **1 m camera-light separation**
- **Compact frame for maintenance**

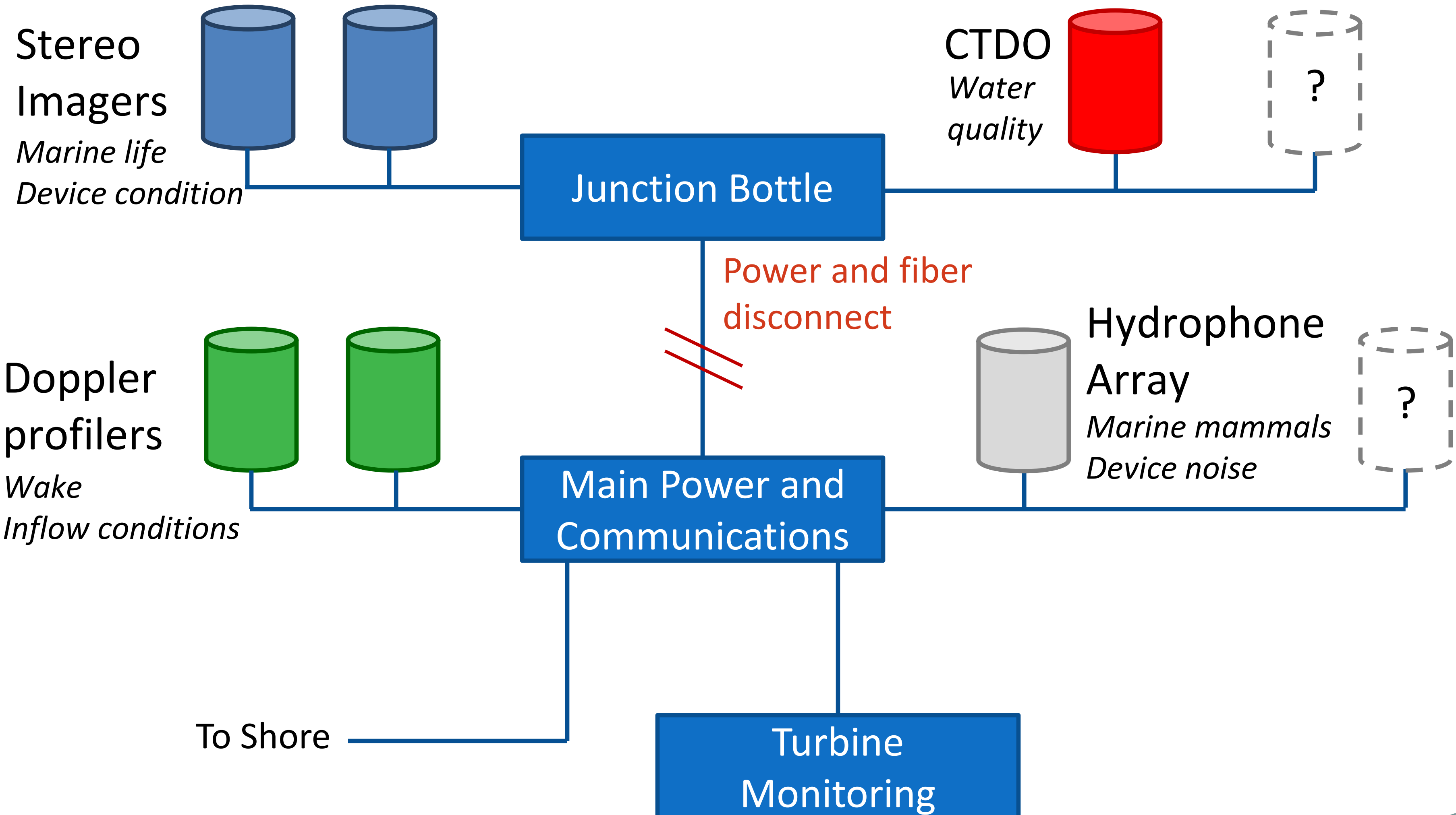
Recovery and Redeployment Concept

- **Reasons for recovery:**
  - Biofouling removal
  - Maintenance and repair
  - Additional instruments
  - Reorientation of cameras
- **Must be recovered independent of turbine**
- **Must be reconnected to turbine power and data systems**



Compact frame concept

Monitoring System Integration



Discussion

- **How much emphasis should be placed on monitoring for blade strike?**
  - Laboratory tests suggest low consequence
  - How much species-to-species, site-to-site, and turbine-to-turbine variability is there?
- **Regulatory mandates are species-specific, but this limits the tools available**
- **Leverage environmental monitoring infrastructure whenever possible – camera can also monitor turbine health (biofouling, vibration)**
- **Post-installation monitoring is essential, but technically challenging – *prioritization required***

Acknowledgments

This project leverages the expertise of many individuals:

- University of Washington: Jim Thomson, Sandra Parker-Stetter, Joe Talbert, Alex de Klerk, Keith van Thiel, Tim McGinnis, Randy Sindelar, and Nick Stelzenmuller
- H.T. Harvey & Associates: Sharon Kramer and David Zajanc
- Sound & Sea Technology: Larry Armbruster
- Sea Mammal Research Unit, Ltd: Dom Tollit, Jason Wood
- Alaska Fisheries Science Center: Rick Towler and Kresimir Williams

This material is based upon work supported by the Department of Energy and Snohomish County PUD.

U.S. DEPARTMENT OF ENERGY

SNOHOMISH COUNTY PUD PUBLIC UTILITY DISTRICT NO. 1